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Modern Concepts of Cardiovascular Disease

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THE EFFECTS OF INTRAVENOUS SOLUTIONS ON PATIENTS WITH AND WITHOUT CARDIOVASCULAR DEFECTS

The popularity of using intravenous solutions in dehydration, shock and nutritional disturbances is well founded, and the benefits derived from the use of these fluids are well known. This popularity is not undeserved for the beneficial results from the use of these fluids are sometimes quite amazing, but the indiscriminate use of them has become widespread and their unfavorable effects, particularly on the cardiovascular system, are attracting more and more attention.

Some of the unfavorable side effects may be observed if fluids are given intravenously to a patient whose plasma proteins are already reduced, and instead of improvement, the patient's progress is retarded by a further drop in the plasma osmotic pressure. Additional fluids may exaggerate an already existing benign pulmonary edema and cause the patient's death. Occasionally too, fluids are given too rapidly and when the cardiovascular system is defective, the additional burden of the increased volume may bring about fatal heart failure.

While it may be stated that intravenous fluids seldom cause bad results, it cannot be said that they never do, and therefore it is important to establish as many safeguards as possible for the protection of the patient. The dangers that may develop from improper use of fluids have been minimized in recent times by the attention given to the proper composition of fluids, and simple rules and tests for their application, especially in shock, have been formulated.

The ability of the cardiovascular system to accommodate added fluids must be considered before the solutions are introduced. We attempted to determine the effect of different fluids on cardiovascular function by observing the changes that occurred when solutions of various concentrations were given in volumes and at rates approximating those employed clinically. Observations included changes in blood and plasma volume, hematocrit, red count, plasma protein, hemoglobin, pulse, blood and venous pressure, respiration, arm to lung and arm to tongue circulation time, vital capacity, electrocardiograms, urinary output and clinical findings. From the results of our study, only the clinical application is proposed in this review. Physiologically, some of our data are of less concrete value because of the lack of unanimity of opinion concerning the changes that occur when heart failure sets in.

Blood and Plasma Volume Changes. The blood and plasma volumes increase in almost direct proportion to the speed with which solutions are given for the first one-half to three-fourths hours, and then tend to drop toward original levels, despite continued administration of fluids up to 1000 cc. When volumes of 2000 cc. or more are given, the drop in one-half to three-fourths hours does not occur, and in fact, the volume keeps increasing though at a markedly diminished rate. This indicates that after a certain length of time, usually 30 to 40 minutes, the speed of injection ceases to be the single most important factor in plasma volume rise. Other factors, such as increased transudation into extravascular areas occur, and diminish, to a certain extent, the effect of the rate.

Increasing the hypertonicity of the solution causes a less marked primary increase in blood and plasma volume. When concentrations of 50 per cent are reached, at least with glucose, the plasma and blood volumes remain practically unchanged or actually decrease during fluid administration. We did not study the effect of increasing the rate of injection of hypertonic solutions on blood and plasma volume, but from our studies with isotonic solutions, we may assume that increasing the rate over 10 to 15 cc. per minute would cause an increase in volumes proportional to the increase in rate.

The decrease in plasma volume that occurred when aminophylline was added to the fluid is in a large part accounted for by increased diuresis and vasodilatation with increased fluid loss by way of the lungs and skin.

Heart failure, if present or produced by fluids, will shorten the usual rise in blood and plasma volume, presumably through increased loss to the extravascular depots, and the greater the degree of failure the less pronounced is the increase for a given type of fluid at a given rate of speed.

Venous Pressure. In general, there is an initial increase in venous pressure which is almost directly proportional to the volume, but not to the rate of

IMPORTANT NOTICE

The Seventeenth Scientific Meeting of the American Heart Association will be held at Hotel STATLER, Cleveland, Ohio. The general cardiac program will be given on Friday, May 30, and the program of the Section for the Study of the Peripheral Circulation on Saturday, May 31.

Admission to meetings will be free to all 1941 paid-up members, upon presentation of their membership card.

To *non-members*, a registration fee of $2.00 will be charged.

injection, when fluids are given. After one-half to three-fourths hours, the venous pressure usually falls regardless of continued introduction of fluids, unless volumes of more than 1000 cc. are employed, when the fall may be delayed. Use of aminophylline will cause an initial decrease rather than a rise, probably due to vasodilatation. Left heart falure is not associated with an increased venous pressure, but right or total failure is. With rates of injection under 50 cc. per minute for isotonic solutions, in patients not in failure or not going into failure, the venous pressure does not exceed 20 cm. of water at any time.

Circulation times, vital capacities, electrocardiograms, pulse, blood pressure and respirations are not materially affected by fluid introduction unless heart failure supervenes.

Urinary Output. Hypertonicity of a solution increases the diuresis almost in direct proportion, the rate of injection and kidney function being constants. Saline solutions tend to be retained and cause little or no diuresis. The onset of diuresis occurs at about the same time as the fall in blood and plasma volume. Congestion on the basis of heart failure increases the diuresis provided renal function remains adequate.

Clinical Changes. Cardiac patients in Classes III and IV tolerated hypertonic solutions of 50 per cent in volumes not exceeding 50 cc. at rates of 10 to 15 cc. per minute without evidence of further cardiovascular impairment; but volumes of more than 50 cc. of hypertonic solutions made 50 per cent of the patients worse. One hundred per cent of the cardiac patients in Class IV were made worse when 1000 cc. of 10 per cent glucose were given, 66 per cent of these patients in Class IV were made worse when they were given 200 cc. of 50 per cent glucose with 8 grains of aminophylline, and 40 per cent of those receiving 200 cc. of 50 per cent glucose in water were made worse.

Cardiac failure of any degree was almost always exaggerated when volumes of more than 50 cc. of hypertonic solution were given. Patients with heart disease of Grades I and II tolerated 2000 and 3000 cc. of isotonic solution satisfactorily if given slowly. If this quantity of solution was given at the rate of 30 to 40 cc. per minute, subjective symptoms of heart failure occasionally developed within the first one-half hour after starting the injection. In these cases the withdrawal of the needle from the vein failed to cut short the attack of heart failure that set in.

Comment. The ability of the cardiovascular system to withstand the added load of injected solutions in our opinion cannot be determined beforehand by any of the tests which we employed. This must not be taken to mean that these tests are useless. If they are used in conjunction with a careful clinical examination, they serve to extend and clarify phases of the clinical analysis. Our chief interest was in the patient who seems well from the cardiovascular standpoint but who is more apparently normal than he really is. While fluids should be given cautiously to all patients, special care must be exercised when there is any impairment of the cardiovascular system, be it little or great, if disaster is to be avoided.

A careful clinical examination of the patient remains an important safeguard in determining the quantity and the speed of intravenous solutions. Any evidence of cardiovascular disease, as hypertension, significant murmurs, cardiac enlargement, shortness of wind on slight exercise, congestion of the bases of the lungs, calls for critical examination before intravenous fluids are administered. Another important saefguard is the withholding of intravenous fluids unless there is genuine indication for their use.

Although the electrocardiograms in our studies failed to show expected changes when the circulation was burdened by added fluids, we believe that in older patients an electrocardiogram should always be done as a part of preoperative work.

Summary. Isotonic solutions in volumes up to 3000 cc. daily in 1000 cc. doses at rates of injection from 20 to 50 cc. per minute may be given without demonstrable cardiovascular changes in non-cardiac patients and cardiacs in Grades I or II compensation. In cardiac patients of Grades III or IV compensation, isotonic solutions in 1000 cc. volumes are definitely dangerous at rates of injection between 20 to 50 cc. per minute. Within four hours, the blood and plasma volumes and venous pressure return to normal levels. If glucose is used, about twice as much fluid is eliminated in the urine as when saline is used.

Hypertonic glucose solutions in volumes up to 1000 cc. at rates of 10 to 20 cc. per minute may safely be given to non-cardiac and cardiac patients in Grade I compensation without fear of untoward cardiovascular consequences. In cardiac patients of Class II, there is some danger in the use of volumes of hypertonic fluids in these amounts and at these rates of administration. In Class III cardiac patients, about 25 per cent will be precipitated in acute left or total heart failure. In Class IV compensation cardiac patients, all (100 per cent) will be made worse by this volume of hypertonic solution.

In volumes of 100 to 200 cc. of strongly hypertonic solutions, about 20 per cent of Grade III cardiac patients and half the Grade IV cardiac patients will be made worse. In volumes of 50 cc. with or without 8 grains of aminophylline, the dyspnea and pulmonary edema will be improved in all Grade IV cardiac patients.

There are no tests of cardiovascular integrity so far known which will enable the clinician to determine beforehand if the cardiovascular system will tolerate fluid therapy. One must fall back on the clinical rule that in the presence of definite clinically demonstrable heart disease with history of symptoms, past or present, fluids should be used intravenously only if indications are present, and then in as limited amounts as possible administered very slowly.

The indiscriminate and purposeless use of intravenous fluids should be discouraged and they should be employed only when indications are clearly present. The established rules concerning the nature of the fluid, the quantity and the speed and method of giving the fluids should be strictly adhered to.

Lastly, in the treatment of any of the signs of left failure with hypertonic solutions with or without aminophylline, amounts not to exceed 50 cc. should be used at rates not to exceed 10 cc. per minute. A violation of these fundamental principles is likely to impede the recovery of patients and even to terminate disastrously for some patients.

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